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ABSTRACT

This publication reports the results of a field study of middle school students using a unified science program, Interrelated Explorations in Science (IES). IES emphasizes the ideas, processes, and values common to all of science and utilizes independent study, gaming, dramatization, and values clarification activities to motivate students to learn. This study was designed to study achievement and attitude change differences, correlation of achievement and attitude, and correlation change. The experimental design, instrumentation, and data analysis are included in detail. Results of the study indicated that the IES program appeared to have had no significant effect on student achievement and only partial effect on student attitudes. Gaming was likewise studied and was found to have a significant impact on student achievement. Three appendices in the report include comments from field test sites, games descriptions, and a report on accreditation standards. (MA)

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Interrelated Explorations in Science for Middle School:

A Report of Field Study

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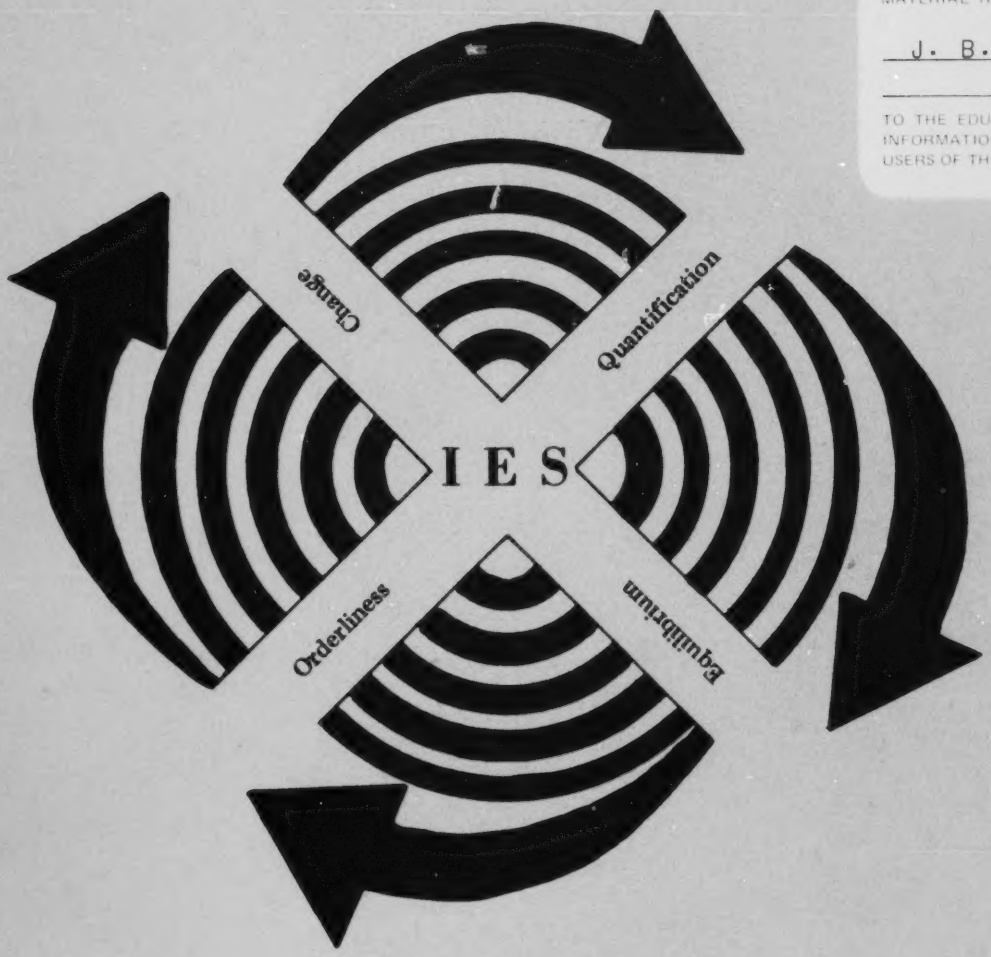

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INTERRELATED EXPLORATIONS IN SCIENCE: A REPORT OF FIELD STUDY

by

Nancy C. Griffin

Fall, 1975

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Gainesville, Florida

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PREFACE

Interrelated Explorations In Science rides at the very crest of a swelling tide. Gradually, but irrepressibly, the unified science movement is becoming the most pervasive force in American science education as science educators become increasingly dissatisfied with existing curricula.

At the one extreme are the dull, watered-down, high school-like texts left over from the fifties. These were and still are essentially all that are available to middle school science teachers. At the opposite extreme are the teacher-proof national programs created in the sixties which generally reach only the most promising students who are both willing and able and who already recognize science as a vital part of their world. Curricula were reorganized around concepts which students "discovered" through "doing science" in laboratories.

But the students of the seventies are different. They are more sensitive to themselves and more aware of their relationship to one another and to their environment. They demand to see that relationship in light of their learnings in science and their lives beyond the school. Competent response to their demands requires that today's curriculum provide both extensive and intensive involvement clearly tied to the real world. What is more, the curriculum must be flexible, recognizing that both students and teachers are inherently individuals as well as environmentally and developmentally differing from one school to the next, from one year to the next, and from one desk or chair to the next. While no curriculum can be made that will work everywhere, it is possible to organize a framework of concepts and to approach them in a setting for learning in such a way that these differences are an asset.

These are some of the concerns that have led to the formulation of the Federation for Unified Science Education (FUSE). Participation in the organization is open to all science educators committed to a unified approach to science teaching and to helping one another in their efforts to improve science education.

The unified science movement may be characterized as a grassroots movement and by the belief that the teacher is the person most qualified to identify the needs and potentials of his or her own students. Further, it is the teacher who can and must assume major responsibility in shaping the program for use in his or her own classroom. The student is accepted as the most vital ingredient in the educational process and the focus of all that goes on to promote learning. General education is viewed as the primary purpose of science teaching in grades K-14. While the specialized sciences have value for the working scientist, they have far less value for students who are attempting to define for themselves the world around them as well as their place in that world.

To understand a tree neither physics nor chemistry nor biology nor meteorology by itself is sufficient. A tree is all of these interwoven and more. Consequently, the unified science approach focuses on the ideas, the processes, and the values common to all of science, on the phenomena and persistent problems in our immediate environment as well as the world at large. This is the essence of Interrelated Explorations in Science.

Interrelated Explorations in Science is a program designed specifically for middle school youngsters, the subjects in the study reported in this monograph. Through emphasis on concrete activities of short duration and through games, creative experiences, and a great diversity of other instructional modes, students maintained a high level of enthusiasm and attention to their learning tasks. By removing blocks to learning, such as extensive reading and complex mathematics whenever possible, and yet teaching these skills where appropriate, students experienced immediate success from the first day in the IES program. At the same time, numerous opportunities were provided for each student to extend him or her self to, but not beyond the limits of, their interests and capabilities. Experiences and learning activities were unified through themes directly related to students' personal lives; hence, the knowledge acquired will likely be of more lasting value to students rather than just preparation for high school.

Positive attitudes both toward science and toward learning in general were recorded. In conclusion, Interrelated Explorations in Science proved to be an exciting, innovative, effective program--an outstanding unified science curriculum for middle school children.

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CONTENTS

	Page
ACKNOWLEDGMENTS	ii
PREFACE	iii
RATIONALE	1
Procedural Support	1
Content Support	4
THE IES PROGRAM	7
Description	7
Objectives	9
Content	10
CONTENT SCHEDULE of INTERRELATED EXPLORATIONS	12
Materials Arrangement	15
Teacher Notes	15
Activities	15
TESTING THE PROGRAM	21
Introduction	21
Field Testing	22
Hypotheses	22
Design	23
Instrumentation	25
Population and Data Collection	27
Data Analysis	30
Significance	38
Testing of Games	42
Hypotheses	43
Design	43
Instrumentation	44

Population and Data Collection 44
Data Analysis 45
Significance 50

APPENDIX A - REPORT ON ACCREDITATION STANDARDS.. 52

APPENDIX B - COMMENTS FROM FIELD TEST SITES 67

APPENDIX C - GAMES DESCRIPTION 72

BIBLIOGRAPHY 74

LIST OF TABLES

TABLE 1 - Number of Students Tested 26

TABLE 2 - Achievement Test Scores Grouped by Achievement Test, School, and Treatment/Contrast (Mean Change Scores) 30

TABLE 3 - Tests of Differences Between Achievement Mean Change Scores on the $CTBS_{III}$ and the SAT for the Treatment and Contrast Groups ($p \leq 0.05$)..... 31

TABLE 4 - Attitude Scores Grouped by Attitude Scale, School, and Treatment/Contrast (Mean Change Scores) 33

TABLE 5 - $\underline{t}$ Tests of Differences Between Attitude Mean Change Scores of Treatment and Contrast Groups 34

TABLE 6 - Attitude Scores Grouped by Attitude Scale, School, and Treatment/Contrast (Mean Change Scores) 35

TABLE 7 - $\underline{z}$ Tests of Differences Between Attitude Mean Change Scores of Treatment and Contrast Groups 36

TABLE 8 - Correlation of Achievement and Attitudes 37

TABLE 9 - Intercorrelation of Science Attitudes Treatment Group 39

TABLE 10 - Intercorrelation of Science Attitudes Contrast Group 40

TABLE 11 - Significant Changes in Pre to Post Correlations.. 41

TABLE 12 - Test Scores Grouped by Game and Treatment/ Contrast (Mean Scores)..... 46

TABLE 13 - t Tests of Differences Between Game Mean Test Scores of Treatment and Contrast Groups 47

TABLE 14 - Test and Retest Scores Grouped by Game and Treatment/Contrast (Mean Scores) 48

TABLE 15 - t Tests of Differences Between Game Mean Test and Retest Scores of Treatment and Contrast Groups .. 49

INTERRELATED EXPLORATIONS IN SCIENCE: A REPORT OF FIELD STUDY

RATIONALE

Because our times demand the recognition and application of basic scientific principles in coping with and effecting constructive change, it is urgent to establish and maintain enthusiasm for the study of science. This need is particularly urgent for the teacher of middle school students.

The middle school grades are critical ones (1). During these years many youngsters begin mentally to sort and arrange their likes and dislikes. Quite frequently during these years students discover subjects in which they will maintain a life-long interest. Still others lose their enthusiasm for some subjects, either because they are not able to gain a firm foundation in the principles or because there is little attempt to relate the subject matter to their own experiences and past observations. Compartmentalization of science subjects may do little to relate the subject to students' experiences (2, 4). In response to this problem, an interrelated exploratory science program was developed at P. K. Yonge.

Procedural Support

Support for IES program content, methods, and innovations can be gathered from many sources. For the purposes of this study, four were given major consideration:

1. Jean Piaget, a developmentalist in educational psychology whose main concern has been to describe and explain the "growth and development of intellectual structures and knowledge" (12, p. 2);

2. Robert M. Gagne (9), a behaviorist in educational psychology who is concerned with how learning occurs;

3. Descriptions of the aims of the unified science movement (6); and

4. State accreditation standards (11).

The first, Piaget, has contributed a description of the general train of intellectual development through observing, describing, and analyzing the behavior of children (5, 12). Piaget maintains that the sequence of cognitive development is the same in all children, although the age of attainment of various intellectual structures may differ. Each developmental stage builds upon the preceding stage; however, succeeding stages cannot be reached until the preceding stage is fully realized in the individual, to the point of conscious mastery.

The implication of Piaget's theory for teaching is that the curriculum, teaching methods, and materials must be at the conceptual level of the students' development if learning is to be effective.

Reflecting Piaget's theory, IES recognizes that middle school students are at varying stages of cognitive development. For example, there are variations in attention span, reading proficiency, and modes of thinking. The IES curriculum was developed to provide a broad array of instructional activities to coincide with the many learning readiness levels represented among middle school students. As a conceptual base, it is assumed that students are in some phase of concrete operation development and can apply logical thought to solve problems which deal with actual objects. IES employs a framework of three broad learning levels: I - skill development; II - application of skills to laboratory experiments; and III - problem solving with new associations upon which the entire program is structured.

The learning theorist, Robert M. Gagne, maintains that "learning is a deliberate, active occurrence" (9, p. 14) which stems from a combination of internal states (learning readiness) and from external sources such as programs and teachers. Gagne suggests that a learner does not acquire new knowledge in only one way but proposes eight types of hierarchies (9, pp. 51-107). Examination of the IES program, in light of Gagne's hierarchy, shows that the activities require participation in seven of these eight learning levels. Built into the Interrelated Explorations in Science program are activities for learning by different modes. While IES does not follow the sequence of Gagne's learning types, it does incorporate seven of the eight types which Gagne describes, starting with Gagne's Type 2, called Stimulus-Response learning. This type of Learning is defined by Gagne as a "single connection between a stimulus and a response" (9, p. 56) terminating with a reward for the learner; it is represented in the IES program by such things as piecing together puzzles used in teaching a single concept.

Gagne's Type 3 learning, called Chaining or Sequencing, is exemplified in several of the metric measuring activities of IES. Students are expected to learn and to be able to use accurately the basic units of the metric system. Only when the basic metric units are learned can a student in Interrelated Explorations in Science successfully apply this measurement system to practical and theoretical problems.

Type 4 learning, Verbal Association, Gagne defines as classification of objects. Students are introduced to the reasons for classifying objects in their environment, to the meaning of classification, and to basic schemes for classifying organisms of the plant and animal kingdom.

Gagne considers the first four types of learning to be important in the classroom because of their "ability to aid the learner in dealing with more complex learning" (9, p. 76) The skills levels of Interrelated Explorations in Science have this same function; i.e., providing the basic assets a student must have in order to proceed with more complex learning as found in Levels II and III of the program.

Discrimination Learning is the label Gagne gives to Type 5. At this level the learner is expected to be "able to make different responses to different objects of stimuli in a class of events" (9, pp. 76-77). This kind of learning is the basis of observations in IES. Students are asked to use their five senses--seeing, feeling, tasting, smelling, and hearing--to distinguish between objects. Students first learn how to observe objects as opposed to merely seeing them. To be able to distinguish between objects is a major objective for students of the Interrelated Explorations in Science program.

Gagne's Concrete Concept Learning (Type 6) states that once differences are identified, then similarities within a group must be recognized. The learner is "to focus on the common elements of the stimuli" (9, p. 83). In the IES program this type of associative learning follows basic observations. For example, once a student can identify the difference between a plant and an animal, then a more sophisticated type of observation follows, such as comparing leaf patterns, or comparing the nervous systems of two animals.

Learning Defined Concepts and Rules is Gagne's seventh learning type. Gagne designates a defined concept as one type of a rule. He defines a rule as "an inferred capability which enables the individual to respond to a class of stimulus situations with a class of performances" (9, p. 90). He maintains that the class of performances is related to a class of relations. Because of the complexity of this learning type, Gagne suggests that the only way to determine if this

learning type has been obtained is by observing "a series of behaviors by the learner which culminate in rule learning and to infer some underlying processes or intellectual structure that the learner may be using" (9, p. 91). Interrelated Explorations in Science uses this type of learning as it directs students in the understanding of natural laws. While a student may verbalize the scientific law, his understanding of it is really tested as he manipulates materials in the process of understanding the law's meaning and its applicability to the student's life.

At the top of the learning level hierarchy in both Gagne's theory and in IES is Problem Solving (Type 8). Students at this learning level use both convergent and divergent thinking for solving problems. Gagne says that divergent thinking states a problem "in which the learner is presented with a stimulus situation, and the task for the learner is to develop as many variations on the stimulus as possible" (9, P. 102). This type of problem solving is used most in IES by bulletin board or poster creations, dramatizations, or independent studies.

Convergent thinking, even more than divergent, is employed in the problem-solving stage of IES. This type of intellectual or mental endeavor is based on the expectation of a predetermined correct response. A student uses convergent thinking to grasp a science concept when required to use his previously learned skills and information to solve a problem.

Content Support

Traditional science is subject-oriented with a litany of facts for each subject. But the various science disciplines overlap in content, so until a student grasps ideas that are common to all sciences, his learning will be limited.

Many educators recognize a need for change in science education. Dr. Paul Hurd of Stanford University says,

> The serious challenges facing science education cannot be met within the framework of the existing curricula. . . . This will require a new synthesis of subject matter less oriented to revealing the structure of disciplines . . . Thus we seek a curriculum with more attention to integrative systems and operations that can interweave diverse disciplines. (8, pp. 18-19)

In 1966, a group of educators interested in unified science education organized and met together to share ideas and concerns for public school science education. With the help of a National Science Foundation grant, this organization increased in size and influence, becoming known as the Federation for Unified Science Education (FUSE). It serves both nationally and internationally to encourage local unified science programs that can best

> . . . enable the learner to view science as a single humanistic effort, to understand the full scope and limitations of science, to avoid repetition of subject matter, to learn science in a greater variety of ways than are permitted in traditional courses, and to develop a positive attitude toward science. (10, p. 26)

In nature, science is interrelated. Many science educators are moving toward the view held by those in the Federation of Unified Science that the learner ought to perceive this natural interrelatedness. Dr. Thomas Gadsden, Jr., member of the FUSE board of directors and Curriculum Director for the Correlated Science Program, grades 10-12, at the P. K. Yonge Laboratory School, maintains,

> Outside the classroom is the world. In it all of a student's life activities are intimately tied together. To teach science only as isolated segments while ignoring this interconnected world beyond the classroom walls is misleading and encourages a narrow-minded approach to solving real problems. The unified science approach begins with commonalities that underlie the disciplines (the major concepts, the principles, and the processes of science) and builds to an understanding of the way that they function in the real world as an inseparable whole and to an appreciation of the interface of the scientific endeavor with the society in which it exists. (6)

To the middle school student, science has not yet been fragmented. The Interrelated Explorations in Science program aims at helping students retain the ability to view science in its entirety. IES promotes for students a firm foundation in the commonalities of the science disciplines, directs their understanding of how science relates to everyday life, and fosters the learning of the close association of science with all of society.

Support for IES ideas is gained from the unified science movement, from the standards set by the American Association for the Advancement of Science, and from educational psychologists. As a curriculum it must also meet the State Department of Education standards for science instruction.

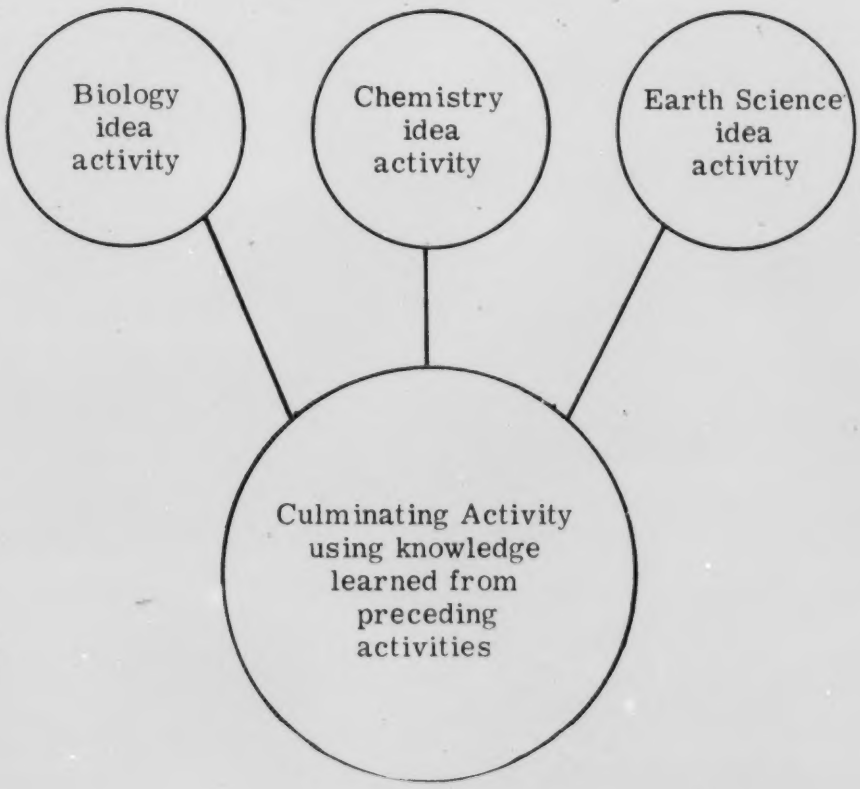
The State of Florida provides 6 science objectives for students to meet. If 2 of the 6 objectives are met, the program is at level 1; if 3 of the 6 objectives are met, a program is on level 2; and if 5 of the 6 objectives are met, then the program is on level 3. While meeting state standards in objectives can be determined only within an individual school and in an individual classroom, the IES materials offer teachers the opportunity to meet all instructional objectives of the state science program at the highest level of excellence.

A full explanation of how Interrelated Explorations in Science completely meets the state standards for students can be obtained only through total use of the program. However, a representative sample of materials has been selected to describe how state accreditation standards are met. These are presented in Appendix A with the standards which they represent.

THE IES PROGRAM

Description

Persuaded that the fragmentation of instruction by disciplines may inhibit rather than facilitate learning of science by the middle school student, P. K. Yonge has developed and tested a unified program for the sixth, seventh, and eighth grades which minimizes the traditional separation of one science discipline from another. The approach emphasizes the common ground upon which all sciences rest, in contrast to approaches which present one science at a time. Thus, students are helped to realize that the sciences are interrelated by using information learned from several instructional topics in activities that integrate several fields of science. The following diagram demonstrates this concept:


Biology idea activity
Chemistry idea activity
Earth Science idea activity
Culminating Activity using knowledge learned from preceding activities

Content is correlated through four major conceptual strands which are introduced in the sixth grade and are continually expanded and reinforced through the seventh and eighth grades. These strands emphasized in the program include:

1. Quantification: Learning how to measure through practicing methods of measuring.

2. Orderliness: Discovering order in biological and molecular systems, structures, interrelationships, and responses.

3. Change: Observing and surveying changes.

4. Equilibrium: Identifying the balancing forces of the universe, earth, living populations, and individuals.

The program is designed to move the student sequentially from initial contact with the subject matter to a firm grasp of the principles involved. Mastery of each step is demonstrated by applying newly acquired knowledge to problem solving. Movement through the program involves three levels:

Level I: Developing basic skills required to understand the principle.

Level II: Designing and implementing laboratory experiments using skills acquired in Level I.

Level III: Employing learning and experiences from Levels I and II, solves problems and discovers new associations.

In applying this three-level approach, the teacher must maintain a degree of flexibility. Although three levels are included in each of the middle school grades, the extent to which each may be emphasized at any given level is determined by the learning readiness of each student.

Another noteworthy characteristic of IES is the emphasis on science as a tool of man to be used in seeking additional information. Science, then, rather than being presented as a subject which provides definitive answers to all functions, is presented as useful only as it facilitates man's inquiry into the nature of the universe and examines alternative solutions to problems of living comfortably and peacefully in the environment. Therefore, the activities in IES are very

frequently open-ended; there is no one right answer. Further, answers may change as new discoveries are made in the activity. Teachers are encouraged to reinforce this discovery aspect of science.

Objectives

Interrelated Explorations in Science bring middle schoolers and fundamental science together in ways that are both educational and highly motivating to students. By drawing on the principles and methods common to all sciences and by relating experiments and discussions to the students' backgrounds and interests, this program provides a new perspective to science instruction in the middle school grades.

The main objectives of IES are:

1. To make learning of science an enjoyable process.

   By capitalizing upon interests common to most middle school students and involving students through games, laboratory activities, interviews, projects, and dramatizations, the program encourages the student to increase his skills and learn science concepts at the same time he is having fun.

2. To involve the student as much as possible through his active participation.

   The teacher becomes primarily a resource person as students proceed with their own activity. There are no lectures, and reading is minimized; however, there is plenty of "doing" by students.

3. To relate science to everyday life and thus foster sensitivity to and appreciation for the natural world.

   This laboratory-centered program is continually interpreted in relationship to the local environment. Whether it is by studying the ecological impact of various human activities on the environment, or by incorporation of a personal project or hobby into the program, students are encouraged to relate their new learning in science to their own world.

4. To develop knowledge of the principles and concepts of science.

   Games, dramatizations, bulletin boards, and other diverse methods are used to teach and reinforce basic science concepts and to stimulate students to internalize basic principles through their personal activities in the classroom.

5. To use materials that are simple in design and low in cost.

   To keep costs at a minimum and to help the child realize that science is a part of his everyday world, materials such as coffee cans, baby food jars, and milk cartons are used as standard equipment.

6. To understand relationships that unite many fields of science.

   Interrelations are emphasized in all grade levels throughout the year. No attempt is made to identify one specific subject area. For example, a plant may be used to demonstrate a physical principle of water movement upward through the roots to stems and leaves. Chemical and/or other pollutant substances are added to the water to determine if any noticeable change occurs in the water movement or in the plant. This kind of activity integrates the traditionally separated disciplines of physics, botany, and chemistry.

Content

The Interrelated Explorations in Science materials may be used in any of the middle school grades--6, 7, 8. Although there is no required sequence which must be followed from the sixth grade through the eighth grade, a guideline presents the sequence used at P. K. Yonge Laboratory School, and, for teachers, each of the activities sheets has a grade level designation on it. However, many of them are cross-referenced to other grade levels since they may be used equally well at that level.

The content schedule which follows is intended to provide an overall view of the IES curriculum. Each vertical column represents a single grade level. Under each grade level the curriculum is

divided into major concept headings. Each of these headings is, in turn, subdivided into instructional topics. The approximate time required to complete each concept heading is noted at the beginning of that section. The times required for some of these topics is noted in parentheses within that subsection.

As an example, the first concept studied in the sixth grade is Quantification. At this particular level it is suggested that the following four aspects of Quantification be considered: (a) the need for measuring; (b) standardization; (c) length; and (d) volume. To complete the entire section takes about three weeks.

Neither for major headings nor for individual activities is there an attempt to arrange subsections according to level of difficulty. Instead, the basis for sequencing is an attempt to build progressively an operational base of information by continually applying knowledge just attained in order to acquire more knowledge. As a result of this approach, until actually used, the program may appear to skip from one concept to another in a disjointed fashion. The program is arranged in this way to insure that new skills are used immediately in subsequent learning activities.

Recognizing that the more actively the student is involved in his own learning, the more likely he is to acquire the concept, the program designs most activities to be done by the students themselves, rather than as demonstrations. Activities are carried out with a partner or in small groups. When enough materials are available, many activities are profitably done by individuals alone.

CONTENT SCHEDULE

of

INTERRELATED EXPLORATIONS

Sixth Grade	Seventh Grade	Eighth Grade
QUANTIFICATION (3 weeks) A. Understand the need for measuring B. Standardization in measuring C. Length D. Volume * * * * ORDERLINESS THROUGH BODY SYSTEMS (8 weeks) A. Skeletal B. Muscular C. Digestive D. Respiratory E. Circulatory F. Excretory G. Nervous H. Reproductive * * * * QUANTIFICATION (4 weeks) A. Area B. Mass	QUANTIFICATION (3 weeks) A. Length B. Mass C. Volume D. Temperature (graphing as needed) * * * * HISTORY OF SCIENCE (a dramatization) (2 weeks) * * * * ORDERLINESS THROUGH PATTERNS (11 weeks) A. Characteristics of the nonliving (3 wks) 1. Air 2. Water 3. Soil 4. Energy B. Characteristics of the living (8 wks) 1. Life activities 2. Plant classification	QUANTIFICATION (2 weeks) A. Mass B. Volume C. Density * * * * ORDERLINESS OF MATTER (7 weeks) A. Characteristics of matter B. Properties of matter 1. Physical 2. Chemical C. Diffusion D. Crystals E. Atomic structure F. Culminating activities 1. Field trip 2. Bulletin board * * * * QUANTIFICATION (2 weeks) A. Length B. Mapping

C. Temperature
D. Graphing

* * * *

ORDERLINESS
(21 weeks)

A. In outer space (4 wks)
   1. Newton's laws of motion
   2. Space travel
   3. Solar system
B. In the atmosphere (3 wks)
   1. Atmospheric layers
   2. Pressure
   3. Temperature
   4. Humidity
C. In matter and energy (8 wks)
   1. Atoms
   2. Molecules
   3. Elements
   4. Compounds
   5. Energy types
   6. Sources of energy
D. In the earth (3 wks)
   1. Types of rocks
   2. Formation of rock
   3. Minerals
E. In living things (3 wks)
   1. Field-outdoor
      a. observing
      b. collecting
      c. identifying
      d. classifying

Total time - 36 weeks

3. Animal classification

* * * *

QUANTIFICATION
(1/2 week)

A. Sampling

* * * *

ORDERLINESS THROUGH INTER-RELATIONSHIPS
(2-1/2 weeks)

A. Food and energy relationships
   1. Prey-predator
   2. Pyramid
   3. Food chains
B. Climax communities
C. Ecological plots

* * * *

CHANGE
(2 weeks)

A. Cycles of
   1. Water
   2. Oxygen
   3. Nitrogen
   4. Life
   5. Meteorology

EQUILIBRIUM
(15 weeks)

A. Understanding Balance (1/2 wk)
B. Climate in Balance (3-1/2 wks)
C. Scale drawing

* * * *

CHANGE
(10 weeks)

A. In the way man lives (3 wks)
B. In the earth (4 wks)
   1. Continental drift
   2. Diastrophism
      a. earth shifts
      b. volcanism
      c. weathering
      d. sedimentation
C. The role of genetics (1 wk)
D. In the appearance of living things (1 wk)
E. Culminating activities (1 wk)
   1. Field trips
   2. Bulletin board

* * * *

QUANTIFICATION
(2 weeks)

A. Temperature
B. Heat energy

* * * *

CHANGE
(6 weeks)

A. Photosynthesis
B. Biological responses

* * * *

1. Fundamentals of climate
2. Water's influence on climate
3. World climatic regions

C. Oceans in Balance (5 wks)
1. Chemical properties of water
2. Physical properties of water
3. Waves and current
4. Sea life

D. Disturbing the Balance (6 wks)
1. Populations
2. Pollution
   a. water
   b. air
   c. waste
   d. herbicides/ insecticides
   e. noise
3. Resources

Total time - 36 weeks

EQUILIBRIUM THROUGH EVERY-DAY CHEMISTRY (7 weeks)

A. Water a solvent
B. Acids, bases and salts
C. Organic substances
D. Inorganic substances
E. Powders
F. Chemical tests of simple substances

Total time - 36 weeks

Materials Arrangement

At the beginning of each major concept section the following items are provided for the teacher's use.

1. Section Overview. At the beginning of each section an overview presents the main ideas of that section and tells how these relate to succeeding sections. The overview also informs teachers of any special arrangements which must be made or of special supplies to be obtained.

2. Behavioral Objectives. A list of objectives, written in behavioral terms, is given for each section. The objectives are limited in scope and are those expected of all students, although other objectives may be attainable. This list represents the minimal, but respectable, level of attainment.

3. Activities Preview. Code numbers and titles of all activities are listed for each concept section in a suggested order. However, the program is flexible enough for each teacher to arrange the materials in the way he believes will be of most benefit to his students. To the left of each named activity is stated the goal to be achieved by its completion.

Within each instructional topic of a concept, Teacher Notes and Activities are included.

Teacher Notes

These notes accompany any activities not self-explanatory. The note may include the intent of the activity, preparations required, safety precautions, evaluation procedures, anticipated results, answer keys, et cetera. Usually these are guidelines, not absolute requirements.

Activities

Student materials are activity-oriented with few exceptions (readings, check points, some miscellaneous items). Only a few of the activities are designed to be used as demonstrations by the teacher since experience has shown that the more the student is

involved, the more easily he acquires the concept. Most of the activities are designed to be done in partnerships or teams of two students, although if enough materials are available, activities may be profitably done individually. Activities are short action-oriented investigations with very specific objectives which can in nearly all cases be completed in a single class period by every student. Faster students may be able to complete two or, in some cases, three activities in each class period.

The following format is standard for each activity.

(Activity Code Number)

(Title of Activity)

Student's Name_____

Introduction (optional)

(1) Purpose

(1) Materials

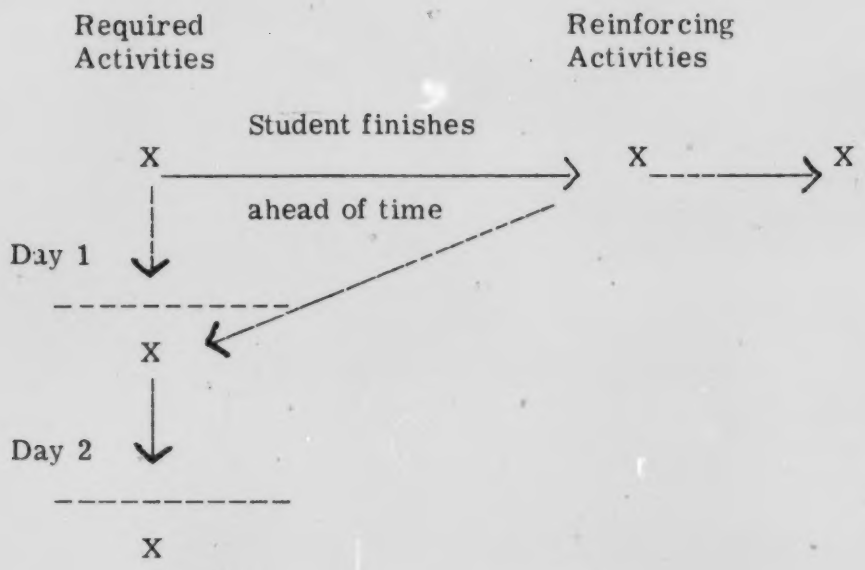
(1) Procedure

* Observations/Results

* Conclusions

*Always to be completed by student.

Daily Individualization. Individualization in the IES program as taught at P. K. Yonge occurs on a daily basis. Students are not encouraged to separate and work alone for several days. Instead, the class is kept together as a unit. The activities, however, are very short. Slower students will require the entire period to complete the activity, while faster students may complete them in less than half that time. Rather than allow the faster student to go on to a new idea or to waste his time, he is directed to a reinforcing activity closely related to the topic being studied. These support activities are intended to challenge the student or to give him another perspective of the topic.



From time to time, the benefits of using a peer-helping relationship are realized by teaming a slow student and fast student together. With introductory activities particularly, it is not necessary to use all of the activities. Some might be selected for total group participation and others be used as needed to reinforce learnings of small groups, teams, or individuals. Only the individual teacher is qualified to determine how and which activities should be used for all students.

Independent Study. At the eighth grade level after the class has completed at least half the year's work, independent study can be used as a worthwhile alternative. If some students seem to become somewhat bored with normal class activities, the teacher might select a fairly general topic and allow them to choose a specific point to study and prepare an individual or small group report. Oral reports are a good way to share information among the class members, but they are also very time consuming and can lead to renewed boredom Written reports are quicker, but cannot be easily shared.

Games and Gimmicks. Experience has shown that the higher a student's enthusiasm, the higher his motivation to learn. Enthusiasm is heightened by varying the activities frequently and imaginatively. Games help some students retain information more successfully than do traditional teaching methods. Another way of heightening enthusiasm is by involving students as completely as possible, both in mind and body, in the activities. Consequently, the activities of IES are sprinkled liberally with games and gimmicks which are intended to supplement, enrich, and reinforce. Card games, puzzles, word

games, competitions, board games are all used. Students can be very successful at creating their own games. Teachers should have students create games whenever it seems feasible.

Dramatizations and Role Playing. Another exceptionally successful technique is the use of dramatizations and role playing. These are excellent for stimulating creativity and for total body involvement. A number of these types of activities are already included in IES, but teachers are further encouraged to use drama in place of some other form of activity or to supplement an activity.

Value Clarification. Several activities include portions that concern value clarification. The emphasis here is on students' becoming aware of their own attitudes and values rather than on moralizing.

Supplementary Learning Materials. Since learning in this program is acquired primarily through activities, there is no need for a high level of proficiency in reading. Yet there are some activities which will need to be supplemented by reading from a text. There is no single text that is adequate to meet the needs of middle school students. Consequently, it is recommended that a multi-text approach be used. In addition, audio-visuals available to local schools should be used liberally to insure that those students experiencing difficulty with printed materials can learn through listening and viewing.

Check Points. Short tests (check points) are given as frequently as possible, generally about once a week. The check points are not intended to prove how much a student does not know. They may appear unduly simple, but the intent is that no child should suffer a feeling of excessive defeat. They are designed to determine whether the student has comprehended the underlying ideas of the activities (in most cases, excluding the readings). Generally, this is accomplished by asking questions that appear to be unrelated to the topic, but that, in fact, require the student to apply the ideas and processes he learned through the activities. In some cases games and crossword puzzles are used as check points. It should be remembered that check points test the IES program and the teacher as well as the student.

Miscellaneous.

Films. We recommend that films be used liberally to supplement, explain, and reinforce. A listing of the films used at P. K. Yonge is available. However, teachers need to select films from their own county offerings.

Field trips. Out-of-door activities and visits to interesting places in the community can be highly motivating and rewarding. IES suggests using field trips as culminating activities for many of the instructional sections. Field trips can be one of the key ways of helping students to relate their classroom learnings with their daily world. However, trips should be planned around specific purposes and students should understand what is expected of them. Obviously, the specific field trips used at P. K. Yonge are accessible only to those teachers in the Gainesville area. In most cases the same or similar purposes can be met using facilities available in other communities.

Bulletin boards. The planning, construction, and evaluation of bulletin boards is another "summing up" activity that can be highly successful. Each small group of students takes a topic that has been studied, does an in-depth analysis of the topic, and then makes a bulletin board that will explain the topic to the class. Every student is in one group, and each group has a different topic.* When all groups are finished, each group evaluates all of the bulletin boards except its own. In this way, students not only study one topic in depth, but they also review and see a summary of other topics they study. This activity is also important for encouraging creativity, group cooperation, and critical evaluation.

Guest speakers. One way to put students' learning into a real world setting is to have guest speakers from the community come to talk with the class. Suggestions for appropriate types of guest speakers are given for most sections in the section overview.

Models. In many parts of this program models are used to help explain an event, an interaction, a system, et cetera. The model may be a physical model such as a torso or model skeleton. It may be a verbal model or a pictorial model. In every case, it is important to stress that no model depicts total reality. A model is a simplification. It emphasizes one part of the thing it represents but it ignores or misrepresents most of the other parts. The purpose for using a model is to help students visualize a concept. Unfortunately, too often the

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*The groups work within a time limit. They may be allowed one day to analyze topic and plan display and three days to complete the bulletin board, but there are no limitations (other than space) on how they make their bulletin board.

students accept the model as a totally accurate representation of real life. It would have to be real life to accurately and totally represent real life. Then of course it would not be any simpler to understand. Students should be guided to make this distinction whenever models are used.

TESTING THE PROGRAM

Introduction

The Interrelated Explorations in Science program is the product of some three years of research and development. Topics and activities which remain as the final product are those which have survived the fires of a number of public school classrooms over the State of Florida. In short, what remains, works!

The IES program capitalizes upon a wide variety of techniques for motivating students to learn. A few of the more common include: manipulating laboratory equipment in experimentation; independent (self-directed) study by a student; dramatizations (role playing) of ideas; clarifying attitudes and values toward specific topics; and using puzzles and games.

Some of these techniques are used in most science classrooms or in other classes a student might attend during his learning day. Games, as a learning device, are often a novelty in a classroom. However, games have been designed as an integral part of the IES program.

To be assured that the entire Interrelated Explorations in Science program would be suitable for all students in grades 6, 7, and 8, a broad field testing program was initiated. Some 2,000 students throughout the State of Florida were involved in using the IES program. With such a large number of students and teachers testing the program, it was recognized and expected that limitations as well as biases would appear in the study.

In order to establish a firmer data base from which to draw conclusions on the effectiveness of the IES program, a specialized study was designed from within the IES tests. As a second aspect of the total program, a more limited study has been to determine if the IES games have any effect upon learning of specific science ideas.

Field Testing

Hypotheses

The field test program was designed and carried out to generate data that would confirm or refute a set of hypotheses. The hypotheses related to achievement, attitudes, correlations between them, and correlation changes. They were:

1. Achievement change differences

   There is no difference between the mean Comprehensive Test of Basic Skills (Level III) change scores of treatment and contrast groups composed of seventh and eighth grade students.

   There is no difference between the mean Comprehensive Test of Basic Skills (Level II) change scores of treatment and contrast groups composed of sixth grade students.

   There is no difference between the mean Stanford Achievement Test change scores of treatment and contrast groups composed of seventh and eighth grade students.

2. Attitude change differences

   There is no difference between the mean change scores of treatment and contrast groups composed of seventh and eighth grade students on four dimensions* of the Science Attitude Scale.

   There is no difference between the mean change scores of treatment and contrast groups composed of sixth grade students on four dimensions of the Science Attitude Scale.

   There is no difference between the mean change scores of treatment and contrast groups composed of seventh and eighth grade students on four dimensions of the Myself as a Scientist Attitude Scale.

   There is no difference between the mean change scores of treatment and contrast groups composed of sixth grade

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*Evaluation, potency, activity, and personality.

students on four dimensions of the Myself as a Scientist Attitude Scale.

3. Correlation of achievement and attitude

   There is no correlation between scores on the Comprehensive Test of Basic Skills (Level III) and scores on each of four dimensions of the Science Attitude Scale and Myself as a Scientist Attitude Scale for the treatment group composed of seventh and eighth grade students.

   There is no correlation between scores on the Comprehensive Test of Basic Skills (Level III) and scores on each of four dimensions of the Science Attitude Scale and Myself as a Scientist Attitude Scale for the contrast group composed of seventh and eighth grade students.

4. Correlation change

   There will be no difference between pre and post intercorrelations of the Comprehensive Test of Basic Skills (Level III) and four dimensions each of the Science Attitude Scale and Myself as a Scientist Attitude Scale for the treatment group composed of seventh and eighth grade students.

   There will be no difference between pre and post intercorrelations of the Comprehensive Test of Basic Skills (Level III) and four dimensions each of the Science Attitude Scale and Myself as a Scientist Attitude Scale for the contrast group composed of seventh and eighth grade students.

Design

Hypotheses were tested using a nonequivalent control group design (3, pp. 47-50) without treatment randomization. This design may be visually represented as:

Treatment group	O	X	O
Contrast group	O		O

where O = observation,

X = treatment, and

dotted line = nonequivalence of groups

The total treatment group was composed of sixth, seventh, and eighth grade students at four schools. The total contrast group was composed of sixth, seventh, and eighth grade students at four schools. Since P. K. Yonge had students in both treatment and contrast groups, the total number of schools was seven.

Observations were pre- and posttests on a science achievement test and on four dimensions each of two science attitude scales. The treatment was the Interrelated Explorations in Science program. The contrast was the science curricula common to each school.

It should be noted that this design has certain limitations. As stated above, there was no randomization of treatment. This means that assignment of schools to either treatment or contrast groups may have introduced a bias. This bias may be a source of internal invalidity. According to Campbell and Stanley (3, p. 5), "Internal validity is the basic minimum without which any experiment is uninterpretable: Did in fact the experimental treatments make a difference in this specific experimental instance?"

In addition, this design has suffered from extensive unplanned student mortality. That is, many students who were pretested were not posttested. This mortality may have seriously biased the results and is, therefore, a threat to the internal validity of the study.

A third limitation of the design is that it is open to several sources of external invalidity. Campbell and Stanley (3, p. 5) state that "External validity asks the question of generalizability: To what populations, settings, treatment variables, and measurement variables can this effect be generalized?" The sources of bias possible in this design are the interaction of testing and treatment, the interaction of selection and treatment, and reactive arrangements. Since testing did not involve particularly novel tests or novel testing situations in terms of both average classroom situations and the treatment itself, this source of invalidity was minimized. Reactive arrangements as a source of invalidity were minimized by the use of whole classrooms as the treatment unit. However, the treatment itself may or may not have been particularly novel in its classroom application, depending on how the teacher employed the treatment.

The main source of external invalidity is the interaction of selection and treatment. Since selection methods were not random and were biased in favor of those teachers' classrooms in which the teachers saw the greatest lack in their own program, those selected may differ from the population to which generalizability is desired. As Campbell and Stanley (3, p. 19) note:

> . . . it would seem well for research reports to include statements as to how many and what kind of schools and classes were asked to cooperate but refused, so that the reader can estimate the severity of possible selective biases. Generally speaking, the greater the amount of cooperation involved, the greater the amount of disruption of routine, and the higher our refusal rate, the more opportunity there is for a selection - specificity effect.

It can be stated in a relative sense at least that, although less rather than greater cooperation was asked, researchers have no way of knowing whether they have contributed to greater rather than less disruption of routine. There definitely has been a higher rather than lower refusal rate. Thus selection and its interactions may be sources of invalidity. Just how severe these threats are to the validity of the study, the researchers have no way of knowing.

Instrumentation*

Two types of test instruments were selected for use in order to compare students using the IES program (field test sites) with those using other programs (contrast sites). These were an attitudinal measure and a standard achievement test.

The science section of two types of achievement tests were used: the 1973 Stanford Achievement Test and 1973 McGraw Hill Comprehensive Test of Basic Skills (CTBS).** The reason for using two different achievements tests devolved from the desire to obtain and use a new achievement test. It was only after having begun administering the 1973 Stanford Achievement test in Lee County (field

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*A breakdown of tests used and number of students taking each test are given in Table 1.

**Level II was administered to sixth grade students. Level III was administered to seventh and eighth grade students.

TABLE 1

Number of Students Tested

School	T/C	CTBS[§]						SAT						Science Attitudes					
		Pre			Post			Pre			Post			Pre			Post		
		6	7	8	6	7	8	6	7	8	6	7	8	6	7	8	6	7	8
Bunnell	T		42	86		42	86								25	77		35	81
Williston	C		81	49		81	49								49	43		61	45
Fessenden	T	42	39	40	42	39	40							41	40	41	42	44	43
Palatka	C													120	120	120	120	120	120
P. K. Yonge	T	50	25	50	50	25	50							50	25	50	50	25	50
P. K. Yonge	C		17			17									17			17	
Lee	T								120	54		120	54		106	49		106	49
Cypress	C									89			89						89

[§]Level II administered to sixth grade students
Level III administered to seventh and eighth grade students

Abbreviations:

T/C Treatment or Contrast group
CTBS Comprehensive Test of Basic Skills
SAT Stanford Achievement Test

and control sites) that the CTBS achievement test was obtained. Because the IES project director felt that the CTBS test was more appropriate for use in this program, it was substituted for the remainder of the untested schools.

Scales measuring attitude toward science are limited. While a few attitude tests do exist, most are too complex for students at the sixth, seventh, and eighth grade levels. James J. Gallagher (7) has developed and tested several semantic differential tests, including one for "Science" and "Myself As A Scientist". Both attitude scales are readable and simple in design. These attitude measurement scales were selected because they seemed to be the best available for use with middle school students. Each of these tests uses a bi-polar, five-point differential scale that is divided into four categories--evaluation, potency, activity, and personality.*

Although the attitude scales had been field tested, certain limitation with their use may exist. Instead of the eight different dimensions constructed by Gallagher, the researchers suspect there are fewer than that. If this is true, then there may be significant attitude differences present which have been obscured by breaking the data into eight small pieces. Such a limitation could easily lead to a bias in favor of finding no significant differences.

Population and Data Collection

School Selection. After it became apparent that the IES program would very likely fill a critical need in the middle school science classroom (on both state and national levels), a drive-in conference was organized and held at the P. K. Yonge Laboratory School (July, 1973) for the purposes of introducing the program to school representatives from around the State of Florida and obtaining field test schools. Administrators, science supervisors, and middle school science teachers from the North Central part of Florida were invited to attend.

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*Some samples of the kinds of choices included on these tests are: (1) On the Science attitude test, students rate responses on a continuum including choices from "interesting" to "boring" or from "active" to "inactive". (2) On the Myself As A Scientist test, students rate responses on a continuum including choices from "valuable" to "worthless" or from "busy" to "doing nothing". Tests from ERC Science Program, copyright 1968 Educational Research Council of America.

At the conference the basic approach and rationale behind Interrelated Explorations in Science were explained to those attending. In addition, IES student materials were made available for teacher examination. Conference participants were invited to use the materials in their entirety, or as a supplement to their own science programs, during the academic school year of 1973-1974. Three schools elected to use the total IES program as presented and two chose to use it as a supplement to their existing courses of study in science. These five schools, then, served as sites for a nine-month field test of the program. Teachers selected for both treatment and contrast groups were those who volunteered to participate in the study.

While offering all schools participating in the conference the use of the IES materials, it was decided that only those schools using the IES materials as the basis of their entire science program should be used as representative field test sites for the IES materials. Three schools in different type communities fell into that category. They were:

1. Lee Middle School in Ft. Myers, Florida. On the West Coast of Florida, Ft. Myers is a resort city with a population of approximately 30,000 people. Lee Middle School is in a predominantly black neighborhood. The students who attend the school are almost all from homes at the low socioeconomic level.

2. Bunnell High School located in a small rural town of Bunnell located on the East Coast of Florida. It has a population of approximately 12,000 and the school serves the entire county.

3. Fessenden Middle School located near the city of Ocala, but serving the rural northern section of Marion County.

It was recognized that selecting control schools to offer student types which will match those from field schools is, indeed, a study within itself, so only an approximation of community types was attempted.

Cypress Middle School, also in Ft. Myers, was chosen as a control group since it was in the same county. However, the students who attend are predominantly from homes at the mid to upper socio-economic level.

Palatka Middle School, a county-wide school serving all of the predominantly agricultural county, volunteered to serve as a second control site. Williston High School, located in a rural, agricultural community of Williston, was selected as a third control site.

Field Test Limitations. The same degree of control over variables which allows the laboratory investigator to analyze statistically his data with confidence simply does not exist in a test design such as the one reported in this work. That certain limitations and biases will occur in the conduct of a program test should be taken for granted.

It is well, however, that the major test limitations be identified so as to facilitate the most accurate evaluation of the program. The major limitations encountered in this study were:

1. A greater disposition on the part of teachers in their first year of teaching to elect the entire program as contrasted with a lower adoption rate among older teachers who already had established science programs. This, in general, tended to "throw" the young teachers without programs of their own into the treatment groups while the more established teachers served more often as part of contrast groups.

2. The failure of some teachers to understand the procedures for testing or failure to carry out the procedures in a meaningful way. Unfortunately this limitation forced the invalidation of a substantial number of tests, reducing the final acceptable testing population to approximately 500 treatments and 200 contrasts for the achievement tests and 500 treatments and 500 contrasts for the attitude tests.

3. Selection of socioeconomically and culturally comparable schools for paired treatment and contrast testing sites. The factor of reliance upon voluntary acceptance of the IES program restricted the degree to which comparable test populations could be incorporated into the study.

4. The limited number of teachers who elected adoption of the entire IES program at all middle school grade levels. This prevented a randomization of treatments.

Data Analysis

To test hypotheses about achievement differences, similar tests were run on CTBS and SAT data. In the CTBS case, a t test was calculated between mean change scores of treatment and contrast schools. In the SAT case, with only one treatment and one contrast school, a z test was calculated between student change scores. A summary of achievement test data is in Table 2.

TABLE 2

Achievement Test Scores Grouped by Achievement Test, School, and Treatment/Contrast (Mean Change Scores)

Test	Grade	T/C	School	N	$\overline{C}$
$CTBS_{III}$	7 & 8	T	Bunnell	128	5.06
	7 & 8	T	Fessenden	78	2.72
	7 & 8	T	P. K. Yonge	87	3.11
	7	C	P. K. Yonge	18	5.44
	7 & 8	C	Williston	128	4.23
$CTBS_{II}$	6	T	Fessenden	39	3.21
	6	T	P. K. Yonge	49	2.69
SAT	7 & 8	T	Lee	168	2.71
	8	C	Cypress	89	3.60

Results of the t and z tests are in Table 3. Neither test was significant at the 0.05 level of significance. Thus there is failure to reject the hypothesis that there are no differences in achievement between treatment and contrast groups with 95% confidence.

TABLE 3

Tests of Differences Between Achievement Mean Change Scores on the $CTBS_{III}$ and the SAT for the Treatment and Contrast Groups ($p \leq 0.05$)

Test	Statistic	df	Computed Value*	Table Value
$CTBS_{III}$	t	3	-1.161	±2.353
SAT	z	N.A.**	-0.959	±1.960

*A positive value states that the mean of the treatment group is larger than that of the contrast group.

A negative value states that the mean of the contrast group is larger than that of the treatment group.

**Not Applicable

It should be noted that it was necessary to employ two different tests of significance. In the CTBS case, the unit of selection was the group of students taught by the selected teacher. It was appropriate, therefore, to use this group as the unit of analysis. Since there was only one group of students taught by the selected teacher in the SAT case, a different test was employed which used each student as the analytical unit.

To test hypotheses about attitude differences, t tests were run between mean change scores of treatment and contrast schools on four dimensions each of the Science Attitude Scale and Myself as a Scientist Attitude Scale. Two tests were run--one using data from seventh and eighth grade students and one using data from sixth grade students. Tables 4 and 6 summarize attitude data. Tables 5 and 7 show the results of the tests. As noted in the latter tables, both the seventh and eighth grade sample and the sixth grade sample show a significant difference between treatment and contrast groups on the personality dimension of the Science Attitude Scale (0.05 level of significance). In addition, the sixth grade sample had a significant difference on the potency dimension of the Myself as a Scientist Attitude Scale (0.05 level of significance). Thus in each but these three cases, we fail to reject the hypothesis that there are no significant differences in attitude between treatment and contrast groups with 95% confidence (see Appendix B).

For all grades the hypothesis that there are no significant differences in the personality dimension of the Science Attitude Scale between treatment and contrast groups with 95% confidence was rejected. This means that the students in the treatment group perceived the subject science as being significantly more friendly and less detached and aloof than did corresponding students in the contrast group. For students in grade six the hypothesis that there is no difference in the potency dimension of the Myself as a Scientist Attitude Scale with 95% confidence was rejected. Sixth grade students in the treatment group appear to be saying "If I were a scientist, I would feel competent and powerful" to a significantly greater degree than do their contrast group counterparts.

To test hypotheses about the significance of correlations between achievement and attitudes, correlations were calculated between $CTBS_{III}$ and four dimensions each of the two attitude scales. These correlations were then compared with 0.00 correlation by means of a z test. This was done separately for both pre- and posttests. As noted in Table 8, there were two significant correlations, both in the treatment group. One was the correlation between pretests of achievement and the activity dimension of the Science Attitude Scale. The other was between posttests of achievement and the personality dimension of the Science Attitude Scale. However, in both cases the amount of variance in common between achievement and attitude scores is only 4%. This is such a trivial percent of total variance that the interpretive value of the significant finding should be discounted.

TABLE 4

Attitude Scores Grouped by Attitude Scale, School, and Treatment/Contrast
(Mean Change Scores)

Grades 7 & 8

Test	T/C	School	N	Eval.	Pot.	Act.	Per.
Science	T	Bunnell	102	0.81	-0.07	0.46	0.65
	T	Fessenden	73	-0.08	0.25	0.29	0.00
	T	Lee	159	0.77	-0.14	0.43	0.16
	T	P. K. Yonge	83	-0.53	0.30	-0.65	-0.08
	C	Palatka	435	-0.98	-0.50	-0.80	-1.00
	C	P. K. Yonge	19	-1.00	-1.42	-2.21	-1.05
	C	Williston	90	0.34	0.04	0.40	-0.12
Myself as a Scientist	T	Bunnell	100	0.56	0.26	0.30	0.30
	T	Fessenden	74	0.78	0.49	0.99	0.93
	T	Lee	157	-0.11	-0.38	-0.16	0.23
	T	P. K. Yonge	82	-0.32	0.40	0.02	-0.05
	C	Palatka	436	-0.97	-0.21	-0.70	-0.85
	C	P. K. Yonge	19	2.84	0.95	1.42	0.95
	C	Williston	88	0.67	-0.19	0.68	0.26

TABLE 5

$\underline{t}$ Tests of Differences Between Attitude Mean Change Scores of Treatment and Contrast Groups

Grades 7 & 8

Test	Eval.	Pot.	Act.	Per.
Science	1.47	1.87	1.42	2.85*
Myself as a Scientist	-0.64	0.02	-0.30	0.46

* for $p < 0.05$, $\underline{t} > \pm 2.015$

\+ Mean of treatment group higher than mean of contrast group
\- Mean of contrast group higher than mean of treatment group

TABLE 6

Attitude Scores Grouped by Attitude Scale, School, and Treatment/Contrast
(Mean Change Scores)

Grade 6

Test	T/C	School	N	Eval.	Pot.	Act.	Per.
Science	T	Fessenden	38	0.74	0.55	0.71	1.13
	T	P. K. Yonge	42	-0.88	0.67	0.57	-0.19
	C	Palatka	114	-0.53	-0.33	-0.37	-1.04
Myself as a Scientist	T	Fessenden	38	1.16	0.50	0.05	-0.34
	T	P. K. Yonge	42	1.48	0.26	-0.02	0.88
	C	Palatka	117	0.15	-0.88	0.30	-0.91

TABLE 7

z Tests of Differences Between Attitude Mean Change Scores of Treatment and Contrast Groups

Grade 6

Test	Eval.	Pot.	Act.	Per.
Science	0.92	0.54	1.92	2.53*
Myself as a Scientist	-0.50	2.03*	0.54	1.71

*for $p < 0.05$, $z > \pm 1.96$

\+ Mean of treatment group higher than mean of contrast group
\- Mean of contrast group higher than mean of treatment group

TABLE 8

Correlation of Achievement and Attitudes
Grades 7 & 8

Test		Science				Myself as a Scientist			
		Eval.	Pot.	Act.	Per.	Eval.	Pot.	Act.	Per.
N = 238		----------Treatment Group----------							
$CTBS_{III}$	Pre	0.16	0.13	0.21*	0.01	0.02	0.06	0.17	0.14
	Post	0.04	-0.08	0.02	-0.20*	0.03	-0.01	0.07	0.10
N = 102		---------- Contrast Group ----------							
$CTBS_{III}$	Pre	0.09	0.02	-0.05	-0.11	0.01	-0.02	0.05	0.08
	Post	0.02	0.05	-0.03	-0.07	0.05	-0.04	0.08	0.08

*Significant at 0.01 level

To test hypotheses about the significance of intercorrelations among attitudes, correlations were calculated among the four dimensions of the two attitude scales. These correlations were compared with 0.00 by means of a z test. All correlations on pre- and posttests for both treatment and contrast groups were significant at the 0.01 level. (See Tables 9 and 10.) Therefore, the hypotheses that there are no correlations among the dimensions of the two attitude scales with 99% confidence were rejected. The large majority of these correlations are both positive and nontrivial. As much as 50% of variance is held in common between two dimensions. Thus it may be inferred that the four dimensions of the two attitude scales are correlated one with the other.

This inference is not surprising for a number of reasons. First, attitudes toward specific related concepts (science and myself as a scientist) are usually correlated. Second, dimensions of each of the concepts are identical and thus should correlate with each other. Third, both concepts and dimensions were structured by Gallagher (7) on a logical basis rather than by empirical means. That is, Gallagher did not subject his attitude scale data to a process such as factor analysis to determine empirically dimensions or concepts appropriate for assignment of scores. If these dimensions or concepts are not empirically verifiable, then researchers caution that their use may lead to obscuring of results.

To test hypotheses about changes in correlations, z tests were run between each pre/post pair of correlations for both achievement and attitudes. As noted in Table 11, there were eleven significant changes among attitudes at the 0.01 level of significance. These changes were split about evenly between treatment and contrast groups. The hypotheses that there were no significant changes with 99% confidence between pre and post correlations were rejected. In all cases, the correlation coefficient increased from pre to post. This means that for both treatment and contrast groups, attitudes became more consistent from the pretest to the posttest.

Significance

The results of this study indicate that the IES program may have no significant effect on student achievement in science and only partial effect on student attitudes towards science. However, this study has suffered from so many limitations and biases as to inhibit inferences about the results. That is, we cannot infer that the IES program does not make a real and significant difference in either achievement or attitudes. All we can state is that these results do not indicate such a significant difference.

TABLE 9

Intercorrelation of Science Attitudes
Treatment Group

Grades 7 & 8: N = 415

	Test		Science				Myself as a Scientist			
			Eval.	Pot.	Act.	Per.	Eval.	Pot.	Act.	Per.
SCIENCE	Eval.	Pre		0.37	0.49	0.61	0.35	0.21	0.26	0.28
		Post		0.39	0.56	0.51	0.50	0.21	0.45	0.39
	Pot.	Pre			0.36	0.16	0.15	0.28	0.16	0.15
		Post			0.41	0.45	0.19	0.25	0.20	0.20
	Act.	Pre				0.50	0.25	0.18	0.33	0.27
		Post				0.53	0.33	0.17	0.35	0.29
	Per.	Pre					0.32	0.19	0.30	0.38
		Post					0.32	0.22	0.28	0.34
MYSELF AS A SCIENTIST	Eval.	Pre						0.51	0.60	0.48
		Post						0.53	0.74	0.61
	Pot.	Pre							0.49	0.37
		Post							0.51	0.45
	Act.	Pre								0.54
		Post								0.68
	Per.	Pre								
		Post								

All significant at 0.01 level.

TABLE 10

Intercorrelation of Science Attitudes
Contrast Group

Grades 7 & 8: N = 545

	Test		Science				Myself as a Scientist			
			Eval.	Pot.	Act.	Per.	Eval.	Pot.	Act.	Per.
SCIENCE	Eval.	Pre		0.48	0.47	0.63	0.34	0.18	0.25	0.22
		Post		0.40	0.64	0.63	0.30	0.24	0.29	0.25
	Pot.	Pre			0.43	0.47	0.23	0.28	0.20	0.22
		Post			0.56	0.53	0.23	0.27	0.23	0.18
	Act.	Pre				0.51	0.14	0.13	0.19	0.12
		Post				0.65	0.21	0.26	0.27	0.19
	Per.	Pre					0.14	0.18	0.18	0.21
		Post					0.26	0.26	0.26	0.26
MYSELF AS A SCIENTIST	Eval.	Pre						0.53	0.67	0.58
		Post						0.64	0.74	0.67
	Pot.	Pre							0.49	0.42
		Post							0.62	0.52
	Act.	Pre								0.66
		Post								0.70
	Per	Pre								
		Post								

All significant at 0.01 level.

TABLE 11

Significant Changes in Pre to Post Correlations

Test	$CTBS_{III}$	Science				Myself as a Scientist			
		Eval.	Pot.	Act.	Per.	Eval.	Pot.	Act.	Per.
$CTBS_{III}$									
SCIENTIST: Eval.				*C+		*T+		*T+	
SCIENTIST: Pot.				*C+	*T+				
SCIENTIST: Act.					*C+				
SCIENTIST: Per.									
MYSELF AS A SCIENTIST: Eval.							*C+	*T+	*T+
MYSELF AS A SCIENTIST: Pot.								*C+	
MYSELF AS A SCIENTIST: Act.									*T+
MYSELF AS A SCIENTIST: Per.									

*Significant at 0.01 level

^{C}Contrast group

^{T}Treatment group

$^{+}$Correlation between scores increased

$^{-}$Correlation between scores decreased

The limitations of this study have been detailed previously. To sum up, most of the limitations have been incurred because of the nature of the study's design as it was applied to a real world situation. These limitations, which may have seriously biased results, are selection of teachers for both treatment and contrast groups, selection of the corresponding school populations for both treatment and contrast groups, student mortality, and the interaction of selection (of teachers and school populations) and the treatment for the treatment group. The first two limitations may have biased the treatment results to such an extent as to obscure any differences due to treatment. The last limitation influences the generalizations the researchers hoped to be able to make to other teachers and classrooms around the state. Unfortunately such limitations abound when working with real people in real world situations instead of with guinea pigs in laboratory situations.

In addition to limitations of design, there were limitations incurred through the use of the attitude scales. Although the attitude scales have been field tested by Gallagher, no data are available on the worth or appropriateness of the scales. Attitude dimensions (evaluation, potency, activity, and personality) of both concepts (science and myself as a scientist) are related to a significant degree in the sample of this study. As previously noted, the researchers of this project suspect that, instead of the eight different dimensions constructed by Gallagher, there may be fewer. If this is true, then there may be significant attitude differences present which have been obscured by breaking the data into eight small pieces. Such a limitation could easily lead to a bias in favor of finding no significant differences. Thus, it is surprising that the results indicate a significant difference on the science personality dimension which favors the treatment group. An inference is therefore justified that the IES program engenders positive attitudes towards the personality of science. If the suspicions mentioned were to be empirically verified--that is, if dimensions have been constructed incorrectly and it were possible to regroup by empirical methods--then it is possible that a greater difference in kind and magnitude of attitudes might be found in this study.

Testing of Games

A second aspect of the IES test study has been to determine if games have any effect upon the learning of specific science ideas.

Hypotheses

The games test program was designed and carried out to generate data that would confirm or refute two hypotheses. These hypotheses were:

1. Games 1 through 9:

   There is no difference between the mean science achievement test scores of treatment and contrast groups of middle school students.

2. Games 8 and 9:

   There is no difference between the mean science achievement retest scores of treatment and contrast groups of middle school students.

Design

In contrast to the somewhat weak experimental design described in the foregoing sections, a relatively strong design was used to test the effectiveness of certain games used in the IES program. The design may be pictured as:

Treatment group	R	X	O
Contrast group	R		O

where R = random selection and assignment,

X = treatment, and

O = observation

This design has excellent internal validity and, in this case, excellent external validity (3, p. 25-27).

The only sources of invalidity that are troublesome in this design are the interaction of selection and treatment and reactive arrangements. Both potential problems were controlled. The interaction of selection and treatment refers to the degree that the sample

population is different from the population to which generalization is desired. Since P. K. Yonge's population draws from a cross-section of Alachua County's school population on several factors (race, sex, and economic level, for example), the researchers are inclined to discount selection/treatment interactions.

Reactive arrangements refers to the degree of novelty of the treatment situation. The treatment may be a novelty in some classrooms--not all classrooms use card games. However, this novelty effect will be present for all who use these game materials. If the novelty is the form of the treatment itself and not of the treatment situation--which is true in this case--then it is appropriate to generalize to other classrooms which use the same novel treatment.

Instrumentation

Because the games were designed to teach isolated scientific facts or principles rather than to study units or disciplines, no validated tests were available. For each game played, a test was developed by the teacher. Each test graded knowledge acquisition and was carefully designed to encompass the materials for both treatment and contrast groups. In all cases, except in the mapping activity, the test was given to the students orally; i.e., the teacher asked the question and students gave a short answer on paper. Both treatment and contrast groups were given the test at the same time.

Population and Data Collection

In this aspect of the IES test study it was decided that variables introduced by many teachers and different testing techniques should be eliminated. The decision was made that only P. K. Yonge Laboratory School teachers and students in grades 6, 7, and 8 would be used, 60 at each grade level. Analyzed along the lines of race, sex, and socioeconomic levels, the P. K. Yonge student population draws from a cross section of both Alachua County and Florida as a whole. Teachers in the program all have at least two years' experience and hold a Master's degree in education (Rank II certificate). Games were played with all three grade levels (sixth, seventh, eighth) over a three-year period.

Prior to each game students in a class were divided into two groups by using a table of random numbers. Each group was given a specific work place, a specific time in which to complete the task, and a specific task--to play a game or to read and answer questions.

Contrast learning material was always carefully selected to cover the science information that was being taught through the medium of a game. Readings were selected to be on or below grade level and of a length suitable to available time.

Data Analysis

The experimental data for the first seven games are summarized in Table 12. Results are listed in Table 13. Especially notable is that all seven $\bar{t}$ statistics are positive. The probability of this happening is less than 0.01. That is, in general, the use of these classroom games has had a positive effect on student achievement. This statement can be made with more than 99% confidence. In addition, students who played group A games did significantly better on the test than did the control group. In general, students who played group B games did not do significantly better than the control group. Thus we infer that all games in group A make a significant difference in students' achievement.

Games were grouped into A and B categories on the basis of how much reading was involved in the game in contrast to the amount of manipulation involved. Group A games stressed manipulation; group B games stressed reading.

It should be noted that group B games did not show consistent results. One vocabulary game of the "go fish" type showed significant differences between student groups while the others did not. To further investigate this inconsistency, two new games were developed and tested. Data are summarized and results are given in Tables 14 and 15. Both games emphasized reading. There were no significant differences on the test between the group of students who played the game and the group who used the dictionary.

However, in the class discussion following the first of these two games, the classroom teacher noticed that the students who were responding to the discussion were those who had played the game. Class discussion was immediately halted; vocabulary words were not mentioned for one week. Then the students were retested to measure their retention of the vocabulary words after one week had passed. This same test/retest situation was repeated for the last game. Results are given in Table 15. The results were mixed: one game showed a significant difference on the retest while the other did not. In addition, three out of the four (re)tests favored the treatment group. In sum, it may be inferred that games of the "go fish" type with a reading emphasis make somewhat of a difference in student achievement. In addition, there is evidence to indicate that these games also contribute significantly to retention by the student.

TABLE 12

Test Scores Grouped by Game
and Treatment/Contrast
(Mean Scores)

Game	Description	Type[#]	Grade	T/C	N	$\bar{X}$	SD
Era Span	Dice & Board	A	8	T	28	9.93	2.02
				C	29	7.31	4.46
Potato Mapping	Carving & Imprinting	A	8	T	28	5.25	1.04
				C	30	4.43	1.50
Invertebrate Squares	Tic-Tac-Toe	A	8	T	25	6.00	2.65
				C	25	4.40	2.58
Archeology Dig	"Go Fish" with Cards	B	8	T	29	4.59	0.82
				C	29	2.97	1.27
Vocabulary Dig	"Go Fish" with Cards	B	8	T	30	6.83	3.25
				C	28	6.46	2.83
Ecology Vocabulary 1	"Go Fish" with Cards	B	7	T	14	8.93	1.64
				C	15	6.93	3.51
Sorting Bacteria	Pass to the Left with Cards	B	7	T	30	5.80	2.57
				C	31	4.68	3.30

[#]Type A = emphasis on activity
Type B = emphasis on reading

TABLE 13

t Tests of Differences Between Game Mean Test Scores of Treatment and Contrast Groups

Game	Type#	Grade	t	* for $p < 0.05$, $t >$
Era Span	A	8	2.84*	±2.01
Potato Mapping	A	8	2.39*	±2.01
Invertebrate Squares	A	8	2.16*	±2.01
Archeology Dig	B	8	5.77*	±2.01
Vocabulary Dig	B	8	0.46	±2.01
Ecology Vocabulary 1	B	7	1.94	±2.05
Sorting Bacteria	B	7	1.48	±2.00

#Type A = emphasis on activity
Type B = emphasis on reading

$p < 0.01$ that all t statistics are in same direction

\+ Mean of treatment group higher than mean of contrast group
\- Mean of contrast group higher than mean of treatment group

TABLE 14

Test and Retest Scores Grouped by Game and Treatment/Contrast
(Mean Scores)

Game	Description	Type[#]	Grade	T/C	N	Test		Retest	
						$\bar{X}_1$	SD_1	$\bar{X}_2$	SD_2
Ecology Vocabulary 2	"Go Fish" with Cards	B	7	T	29	4.28	1.75	4.59	1.82
				C	22	4.32	1.52	4.18	1.82
Weather Vocabulary	"Go Fish" with Cards	B	6	T	26	6.42	2.42	6.50	2.23
				C	23	4.91	3.29	4.91	3.19

[#]Type A = emphasis on activity
Type B = emphasis on reading

TABLE 15

t Tests of Differences Between Game Mean Test and Retest Scores of Treatment and Contrast Groups

Game	Type#	Grade	Test t	Retest t	* for $p < 0.05$, t>
Ecology Vocabulary 2	B	7	-0.09	0.79	±2.01
Weather Vocabulary	B	6	1.85	2.04*	±2.01

#Type A = emphasis on activity
Type B = emphasis on reading

\+ Mean of treatment group higher than mean of contrast group
\- Mean of contrast group higher than mean of treatment group

Significance

The results of this study indicate that games used in the IES program have a significant impact on student achievement. In addition, there is evidence which suggests that the games aid in the retention of knowledge by the students.

Unlike the field test study, the study of games employed a design relatively free from limitations and built-in biases. For example, variability in teachers (selection) was not a problem because the same teacher taught all the students in the study. Non-randomization was not a problem because the students were randomly split into two groups by the teacher. In general, the game design is much stronger than the field design because there were not as many uncontrolled variables. The researcher had more control over the experiment and took care to standardize every facet of the treatment.

In summary, the use of IES games contributes significantly to student achievement. Of particular impact are those games that do not require reading. However, taken together, all IES games help students to learn.

APPENDIX A

Report on Accreditation Standards

P. K. YONGE LABORATORY SCHOOL
Report on Accreditation Standards 1974 - 1975

Subject or Service Area: Science
Level (Circle): Elementary (Middle School) High School

ACC - [2] Instruction:
___ District (1) ___ Elem. (3)
___ Overall (2) x J. H. S. (4) ___ H. S. (5)

Names of Participating Staff: Nancy Griffin, Susan Poor

Page No.	Standard No.	Kind of Standard	Standard Response	Basis of Compliance or Non-Compliance: Includes goal statement and criterion (status); goal statement and criterion of staff action and evaluation data to support (process); and expected outcome and criterion for students and evaluation data to support plus percentage of students reaching standard.
		S-Status P-Process X-Product	Yes/No (S/P) ___% (X only) ___grade level ___(X) only	
172	Level 3AD X-4.256	S P (X)	(Yes) No 90 % / 6 grade	Students will demonstrate their acquisition of knowledge of the orderliness of the universe of which we are now aware by completing activities 1-5, 7 of the IES program on Section B Orderliness 6th grade level or by completing check point of 6th grade Orderliness Section B or by both of the above.
172	Level 3AD X-4.256	S P (X)	(Yes) No 90 % / 7 grade	Students will develop skills and attitudes relative to the observation of every day living by completing the IES activities entitled: T 7 0 Demonstrations with Air A 7 0 P Burn the candle A 7 0 A To Pour Water A 7 0 A Water Moves A 7 0 A Friction } Orderliness Section A or after having completed suitable IES activities in 7th grade Orderliness Section B, write a paper which will describe how plants and animals are alike and different and by successfully completing a bulletin board with a team of students relating to the above topic.

P. K. YONGE LABORATORY SCHOOL
Report on Accreditation Standards 1974 - 1975

Subject or Service Area: Science
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Page No.	Standard No.	Kind of Standard S-Status P-Process X-Product	Standard Response Yes/No (S/P) ___ % (X only) ___ grade level ___ (X) only	Basis of Compliance or Non-Compliance: Includes goal statement and criterion (status); goal statement and criterion of staff action and evaluation data to support (process); and expected outcome and criterion for students and evaluation data to support plus percentage of students reaching standard.
172	Level 3AD X-4.256	S P (X)	(Yes) No 90 % / 7 grade	Students at the middle grade levels will understand that science is a process of learning about the world around him by completing at least 8 activities in both Section B (plants) and Section C (animals) of 7th grade Orderliness or by completing the culminating activity entitled "Ecological Plot Study".
172	Level 3-AD X-4.256	S P (X)	(Yes) No 90 % / 7, 8 grade	Students will recognize that science is not, and probably never will be, a finished enterprise through class discussions initiated by the teacher. Teacher will judge the attainment of this objective by having students name five things to which science has not yet obtained answers.
172	Level 3-AD X-4.256	S P (X)	(Yes) No 90 % / 6, 7, 8 grade	Students will acquire knowledge of the role of measurement in the sciences through completing 10 IES activities dealing with measurement.
172	Level 3-AD X-4.256	S P (X)	(Yes) No 90 % / 8 grade	Students will recognize that there is much to be discovered about how things in the universe behave and how they are interrelated through completing at least 15 8th grade IES activities of change including:

P. K. YONGE LABORATORY SCHOOL
Report on Accreditation Standards 1974 - 1975

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		S-Status P-Process X-Product	Yes/No (S/P) ___ % (X only) ___ grade level (X) only	
	Level 3-AD X-4.256 (continued)			A 8 C S Recording Change R 8 C Eras R 8 C The Drifting Continents A 8 C P Piecing the Puzzle A 8 C P Aging A 8 C P Evolutionary Evidence A 8 C S Observing Differences A 8 C A Cultural Differences in Political Decision Making and by Class Discussions Change Section A
172	Level 1-AD X-4.257	S P (X)	(Yes) No 80 % / 6 grade	Students will demonstrate the acquisition of the knowledge that matter exists in the form of units which can be classified into hierarchies of organizational levels by completing the following IES activities: A 6 O S Elemental Bingo A 6 O S Isolating Oxygen A 6 O A Picture that Element A 6 O S What's Matter? A 6 O P Character Clues } Orderliness Section C

P. K. YONGE LABORATORY SCHOOL
Report on Accreditation Standards 1974 - 1975

ACC - [2] Instruction:
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Subject or Service Area: Science
Level (Circle): Elementary (Middle School) High School

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Page No.	Standard No.	Kind of Standard S-Status P-Process X-Product	Standard Response Yes/No (S/P) ___% (X only) ___grade level (X) only	Basis of Compliance or Non-Compliance: Includes goal statement and criterion (status); goal statement and criterion of staff action and evaluation data to support (process); and expected outcome and criterion for students and evaluation data to support plus percentage of students reaching standard.
172	Level 2-AD X-4.258	S P (X)	(Yes) No 90 % / 6,8 grade	Students will demonstrate the acquisition of the knowledge that the behavior of matter in the universe can be described on a statistical basis through completion of the following activities: R 8 C Transferring Character A 8 C P The Problem Character A 8 C P Penny Pitching A 8 C P Populations Probabilities } Change Section A A 6 O A Scaling the Solar System A 6 O A Planet Hot A 6 O P Constellation Patterns } Orderliness Section B
172	Level 1-AD X-4.260	S P (X)	(Yes) No 90 % / 6,8 grade	Students will demonstrate the acquisition of the knowledge that units of matter interact by completing the IES activities including:

P. K. YONGE LABORATORY SCHOOL
Report on Accreditation Standards 1974 - 1975

Subject or Service Area: Science
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Names of Participating Staff: Nancy Griffin, Susan Poor

Page No.	Standard No.	Kind of Standard S-Status P-Process X-Product	Standard Response Yes/No (S/P) ___ % (X only) ___ grade level ___ (X) only	Basis of Compliance or Non-Compliance: Includes goal statement and criterion (status); goal statement and criterion of staff action and evaluation data to support (process); and expected outcome and criterion for students and evaluation data to support plus percentage of students reaching standard.
	Level 1-AD X-4.260 (continued)			A 8 OA Save all the parts. A 6 8 O An Atom Acting A 8 O P Combining A 8 O P Separating Mixtures A 8 O A Making Molecules } Orderliness Section A A 6 O S Neutralizing Acids & Bases C P 6 O A Cyclic View A 6 O S The Expanding Gas A 6 O P The Empty Container } Orderliness Section C
172	Level 1-AD X-4.260	S P (X)	(Yes) No 80 % / 6, 7, 8 grade	The students will demonstrate the acquisition of the knowledge that all interacting units of matter tend toward equilibrium states and that the sum of energy and matter in the universe remains constant by completing the following IES activities: A 6 O S Containing Air A 6 O S What's Matter? A 6 O P The Empty Container } Orderliness Section C

P. K. YONGE LABORATORY SCHOOL
Report on Accreditation Standards 1974 - 1975

Subject or Service Area: Science
Level (Circle): Elementary (Middle School) High School

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	Level 1-AD X-4.260 (continued)			A 6 O S Molecules in Motion A 6 O S The Expanding Gas } Orderliness Section C A 6, 7 Q S Adding to A 6 Q P Dissolving Mass } Quantification Section A A 8 O A Save all the parts. A 8 O P Combining } Orderliness Section A
172	Level 2-AD X-4.261	S P (X)	(Yes) No 90 % / 7 grade	Students will demonstrate the acquisition of the knowledge that one of the forms of energy is the motion of units of matter by completing the IES activities: A 7 O A Hammer and Nails A 7 O A Friction A 7 O A The Energy Process A 7 O A Cup and Candles } Orderliness Section A
172	Level 1-AD X-4.262	S P (X)	(Yes) No 90 % / 6 grade	Students will demonstrate the acquisition of the knowledge that living things are in constant change by completing the IES reading and activities:

P. K. YONGE LABORATORY SCHOOL
Report on Accreditation Standards 1974 - 1975

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ACC - [2] Instruction:
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___Overall (2) _x_ J.H.S. (4) ___H.S. (5)

Names of Participating Staff: Nancy Griffin, Susan Poor

Page No.	Standard No.	Kind of Standard S-Status P-Process X-Product	Standard Response Yes/No (S/P) ___% (X only) ___grade level (X) only	Basis of Compliance or Non-Compliance: Includes goal statement and criterion (status); goal statement and criterion of staff action and evaluation data to support (process); and expected outcome and criterion for students and evaluation data to support plus percentage of students reaching standard.
	Level 1-AD X-4.262 (continued)			The Skeletal System Muscular System Digestive System Respiratory System Circulatory System Excretory System Nervous System Reproductive System } Orderliness Section A
173	Level 1-AD X-4.263	S P (X)	(Yes) No 80 % / 8 grade	Students will demonstrate the acquisition of knowledge that living things are products of heredity and environment by completing the 8th grade IES activities: A 8 C S Observing Differences R 8 C Transferring Character A 8 C P The Problem Character A 8 C P Penny Pitching A 8 C P Population Probability A 8 C P Earlobes and Tongues A 8 C P Why Some Survive } Change Section A

P. K. YONGE LABORATORY SCHOOL
Report on Accreditation Standards 1974 - 1975

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___ Overall (2) _x_ J. H. S. (4) ___ H. S. (5)

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Page No.	Standard No.	Kind of Standard S-Status P-Process X-Product	Standard Response Yes/No (S/P) ___ % (X only) ___ grade level ___ (X) only	Basis of Compliance or Non-Compliance: Includes goal statement and criterion (status); goal statement and criterion of staff action and evaluation data to support (process); and expected outcome and criterion for students and evaluation data to support plus percentage of students reaching standard.
173	Level 2-AD X-4.264	S P (X)	(Yes) No 90 % / 7 grade	Students will demonstrate the acquisition of knowledge that living things are interdependent with their environment by completing five activities of Section D Orderliness (interrelationships) in 7th grade IES, or by completing the culminating activity entitled "Ecological Plot Study".
173	Level 3-B X-4.267	S P (X)	(Yes) No 70 % / 8 grade	Students will demonstrate proficiency in measuring mass in metric by using balances with which they will be able to convert units of weight into metric. They will complete at least one of the IES activities in the Quantification Section A from weights used in class measuring into metric.
173	Level 3-B X-4.267	S P (X)	(Yes) No 100 % / 6, 7, 8 grade	Students will demonstrate proficiency in measuring temperature with a centigrade thermometer by completing at least two IES Quantification activities in which they must use a centigrade thermometer.
173	Level 3-B X-4.267	S P (X)	(Yes) No 90 % / 6, 7, 8 grade	Students will demonstrate proficiency in calculating volume of length, width, and height; also measure volume by water displacement by completing IES activities (3) entitled:

P. K. YONGE LABORATORY SCHOOL
Report on Accreditation Standards 1974 - 1975

Subject or Service Area: Science
Level (Circle): Elementary (Middle School) High School

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Names of Participating Staff: Nancy Griffin, Susan Poor

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		S-Status P-Process X-Product	Yes/No (S/P) ___ % (X only) ___ grade level (X) only	
	Level 3-B X-4.267 (continued)			A 6, 7, 8 Q S How to Find Volume A 6, 7, 8 Q S Volume Blocks A 6, 7, 8 Q S Volume of Irregular Objects A 7, 8, Q S Volume in Water } Quantification Section A
173	Level 3-B X-4.267	S P (X)	(Yes) No 75 % / 6 grade	Students will demonstrate proficiency in measuring voltage and current in simple circuits and calculate power by completing four activities dealing with electricity in Section B of Orderliness of 6th grade IES program.
173	Level 3-B X-4.267	S P (X)	(Yes) No 80 % / 8 grade	Students will demonstrate proficiency in determining density and specific gravity by the IES Quantification activities entitled: A 8 Q S Density A 8 Q S The Peanut System A 8 Q A A Chilly Ride A 8 Q P See Saw A 8 Q P Detecting Differences with Density } Quantification Section A

P. K. YONGE LABORATORY SCHOOL
Report on Accreditation Standards 1974 - 1975

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173	Level 3-B X-4.267	S P (X)	(Yes) No 80 % / 7 grade	Students will determine the speed of objects by completing the IES activities: R O 7 Speedy Calculation A 7 O P Comparing Mammal Speeds A 7 O P The Fastest of the Chordates } Orderliness Section C
173	Level 1-AD X-4.268	S P (X)	(Yes) No 90 % / 8 grade	Students will identify variables which influence the behavior of the properties of a physical and/or biological system by completing three of the following IES activities: A 8 O S Lysis A 8 O A Plasmolysis A 8 O S The Purple Marauder } Orderliness Section A A 8 C P Ooo Ahh! A Mealworm's Reaction to Hot or Cold A 8 C P Holy Poly Walk } Change Section B
173	Level 1-AD X-4.268	S P (X)	(Yes) No 80 % / 7, 8 grade	Students will use the term "controlled variable" and "responding variable" to describe an experiment after having completed three of the following IES activities:

P. K. YONGE LABORATORY SCHOOL
Report on Accreditation Standards 1974 - 1975

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	Level 1-AD X-4.268 (continued)			A 7 O P Leaves without Light } Orderliness A 7 O P Leaf Light } Section B A 6, 7, 8, EP The Human Pendulum } Equilibrium A 8 C S What's the Pull? } Change Section B A 8 C P Fish Respiration A 8 O A Plasmolysis } Orderliness A 8 O S Lysis } Section A
173	Level 2-AD X-4.269	S P (X)	(Yes) No 90 % / 8 grade	Students will identify the variables which are controlled and those which change an experiment by completing the IES Orderliness activities: R 8 O Controlling Factor } Orderliness A 8 O A Molecules and Membranes } Section A A 8 O S Matter to Matter
175	Level 2-AD X-4.269	S P (X)	(Yes) No 90 % / 7 grade	Students will construct an experiment to determine the effects of one or more variables on a system by completing the IES activity A 7 O P Growing Bread Mold in Orderliness Section B.
179	Level 1-AD X-4.270	S P (X)	(Yes) No 90 % / 6, 7, 8 grade	Students will plot data and interpret results by completing at least two of the IES activities below:

P. K. YONGE LABORATORY SCHOOL
Report on Accreditation Standards 1974 - 1975

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	Level 1-AD X-4.270 (continued)			A 6 Q S Graphing the Height of the Class } Quantification Section B A 6 Q S A Temperature Graph A 7 O P Root Shoot Race } Orderliness Section B A 7, 8, Q P Caterpillar Crawl } Quantification Section A A 7, 8, Q P The Ant Race
173	Level 1-AD X-4.271	S P (X)	(Yes) No 90 % / 7 grade	Students will examine related graphs and tables of data and form an inference of hypothesis by completing IES equilibrium activities. A 7 E S Using Water A 7 E P Beliefs and Benefits of Pesticides } Equilibrium
173	Level 1-AD X-4.272	S P (X)	(Yes) No 90 % / 6 grade	Students will distinguish between an operational and a non-operational definition by completing the following IES activities: A 6 O S Molecules in Motion A 6 O S The Expanding Gas } Orderliness Section C Operational A 6 O S Chemical or Physical Change A 6 O A Universal Vocabulary } Orderliness Section B Nonoperational A 6 O A The Matter of Words

P. K. YONGE LABORATORY SCHOOL
Report on Accreditation Standard 1974 - 1975

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173	Level 1-AD X-4.272	S P (X)	(Yes) No 90 % / 6 grade	Students will describe the essential components of an operational definition by completing the following IES activities: A 6 O S Molecules in Motion A 6 O S Chemical or Physical Change A 6 O S The Expanding Gas } Orderliness Section C
173	Level 2-AD X-4.273	S P (X)	(Yes) No 90 % / 8 grade	Students will demonstrate their ability to construct an operational definition by analyzing and describing a mixture of unknown composition or by completing one of the IES Orderliness activities: A 8 O S Ink Diffusion A 8 O P Separating Mixtures A 8 O P In and Out of Suspension } Orderliness Section A
173	Level 2-AD X-4.274	S P (X)	(Yes) No 90 % / 8 grade	Students construct and demonstrate a test of an hypothesis by completing the IES activity A 6, 7, 8, E P The Human Pendulum.
174	Level 3-AD X-4.275	S P (X)	(Yes) No 90 % / 8 grade	Students will demonstrate their ability to revise a hypothesis by successful performance of the IES Quantification A 8 Q P Hills of West Virginia, Laboratory Experiment which requires them to revise and retest their hypothesis.

P. K. YONGE LABORATORY SCHOOL
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		S-Status P-Process X-Product	Yes/No (S/P) ___ % (X only) ___ grade level (X) only	
174	Level 3-AD X-4.276	S P (X)	(Yes) No 100 % / 8 grade	Students will demonstrate an understanding of science concepts by successful performance on a self-designed laboratory activity or by completing any 10 IES activities which require the use of experimentation.
174	Level 1-AD X-4.277	S P (X)	(Yes) No 100 % / 6, 7, 8 grade	Students will demonstrate their knowledge and skills in use of laboratory facilities through (everyday) participation in IES laboratory activities as the teacher observes and records the success of each student.

APPENDIX B

COMMENTS FROM FIELD TEST SITES

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FT. MYERS: Student Comments

1. I feel the science activities are really good. Science activities help you understand science better. The reason I like them is because they give me a chance to experiment to find the answers. They're a lot of writing but you get a lot more understanding from them.

2. I like the activities because they're something I've never done before. I like them because they're better than working in the textbook. They give you a chance to experiment. I like getting money because when I want to know if I have to work harder or not.

3. I like the activities because I like doing the experiments and they are fun to find out what happens. I like the money we get because the more you get is the higher the grade rises and I like that. I like to start on easy ones then go to hard ones. They give you a chance to experiment and find out a lot of things. I also like it because I can understand some things in other classes for activities I do in here.

4. I think science is fun. If you have enough time there is no reason why you should not have the assignments done. In my last year class I hated science because we had to read right out of the book and we had to write definitions out of the book and I'm very glad it's not like that this year. You don't learn nothing that way.

5. Science is o.k. I like to do experiments. They are better than doing things out of the book and it is something different each day. I like doing things different and doing experiments every day is what I like about science.

6. I think science is the best place in the world. I think it is the best class I have every day. It keeps me going. I can't wait until I get there every day and I think it is just right.

7. One reason I like it is because you can work at your own speed. You can do any 7th grade activity you want to do. And you can do it at any time.

8. One reason that I like the activities is because you work at your own speed, without having to worry about falling behind. Another reason is because you don't have to get them in on a certain time. But there is one thing that I don't like about them is that "they are Hard!"

9. Who ever picked out the way to do the science activities did it well. In my opinion I think that it is fun, but while it is fun, you learn too. There are some kids that really "care" about the activities and some kids really abuse the use of them. It seems that no matter how hard you try to help there still have to be some that just don't care. I'll admit, I was beginning to get "lazy," but I caught myself and I changed. You're doing <u>great</u> with people, keep it up.

10. Well at this school I like science a lot better than I did at my other school because it was boring in my science class. My other school in science all we did was read in the science book and doing weights. It is more interesting down here because we do a lot of different things in science, and I don't just like to be on one thing for a couple of weeks or a month. I like it down here better because you do lots of different things.

11. I like science. It's a lot of fun, sometimes, people bug me to get fed up with the whole thing. I like doing different things. It's simple doing activities I don't like to work out of books all the time. And I don't like to do one thing for a month.

BUNNELL: Teacher Comments (Elliott Palmer)

1. They (the kids) are learning more than ever before. I think it's a great program.

2. The kids who can't read don't realize it; they love the program; they want to be scientists.

3. I think this program is just the thing to hit the kids on the head with.

4. It's a good program, the fast kids really love it.

5. All of the kids are really getting something out of it.

6. It's a good program. Even Mary is using it in the high school.

7. Without this program I think I'd go sell beer.

8. With this program I'm really reaching kids. The quantitative part is the part I must emphasize since the qualitative part is just too much for most of them.

FESSENDEN: Teacher Comments (Eric Johnson)

1. I've seen kids do things this year that they have never done before. Kids who have sat doing nothing in years past are actually trying. They're doing things.

2. It's a very organized program one thing builds on another or leads into another topic.

3. Things are going smoother this year in teaching than I've ever had before.

4. All my kids do some activities within the hour--it keeps all kids interested.

5. Compared to last year, I feel the slow kids have learned so much from these activities because they're responsible for their own learning.

MARION COUNTY: Science Supervisor Comments (Mr. Kerlin)

1. The teachers like the program.

2. It seems to be very successful for those teachers who are using it.

3. Mr. Johnson did the activity on drowning kids, and it really worked well! They all got a big "kick" out of it and learned something too!

4. Charles Dixon likes it!

OCALA: Science Curriculum Co-ordinator Comments (Elaine Lane)

1. I'm really pleased with the way things are going.

2. Another science co-ordinator spoke with me last week. She said at her school there was a real need for more science activity and more individualization in science. She suggested that we get together to write some unipacs for science. I told

her that my schools were doing fine, that we had no need for such. Then I showed her the IES materials. She was so excited about them and would like to begin using them for the rest of the school year.

3. I'm really pleased with how well things are going.

APPENDIX C

GAMES DESCRIPTION

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Invertebrate Squares

The purpose of Invertebrate Squares was to describe different phyla of invertebrate animals. The game was played by overlaying word descriptions on pictures in a game format similar to tic-tac-toe.

Potato Mapping

The purpose of Potato Mapping was to make a contour map from which students would learn to read slopes of a hill, steepness of hill, and identify the function of contour maps. The game required actually cutting a potato and drawing lines around the potato to make a contour map.

Era Span

The purpose of the Era Span game was to identify the eras of time and events of the earth's history that occurred during each era. The game required a game board and dice. Players rolled dice to determine the length of their movement. Specific events in each era of time helped or hindered the individual's movement through the eras of time.

Sorting Bacteria

Sorting Bacteria was a card game of chance. Its purpose was to identify types of bacteria and characteristics unique to each bacterial type. The game format was that of discarding a card that could not be used by a player to make a match.

Vocabulary Games

Archeology Dig
Vocabulary Dig
Ecology Vocabulary
Vocabulary in Ecology
Vocabulary of Weather

In each vocabulary game the purpose was to learn word meanings through a game. Students asked each other for specific matching vocabulary cards similar to the game "Go Fish". Two vocabulary games (Vocabulary in Ecology and Vocabulary of Weather) had drawings as well as words on the cards.

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